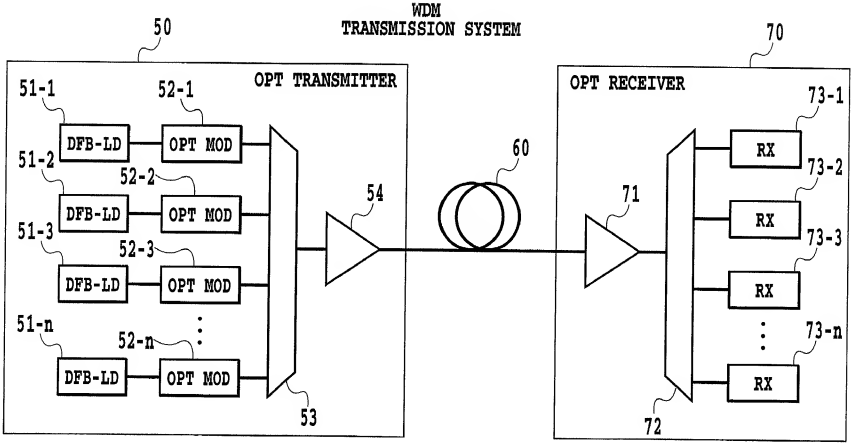


FIG.1
PRIOR ART

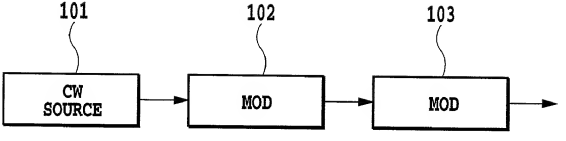


FIG.2

FIG.3A

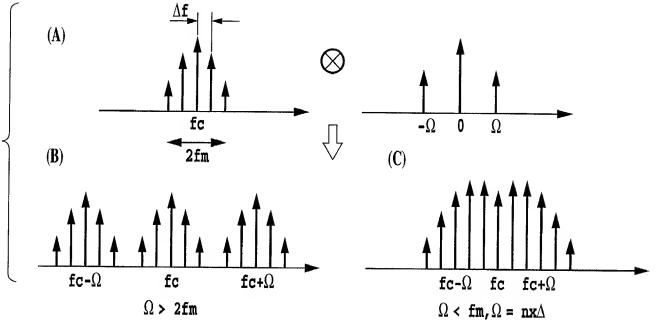
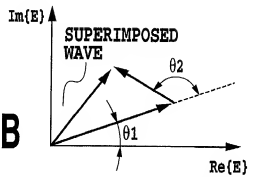
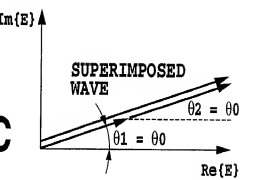


FIG.3B



ADDITION OF TWO MODES WITH DIFFERENT PHASES

FIG.3C



ADDITION OF TWO MODES WITH SAME PHASE

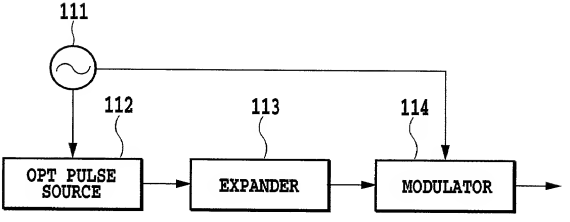


FIG.4

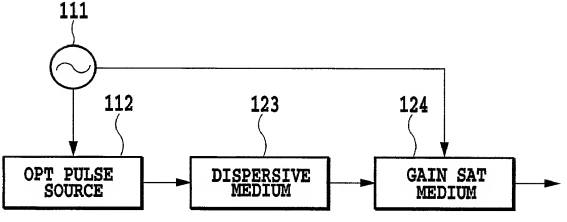

111
112
123
124
OPT PULSE SOURCE
DISPERSIVE MEDIUM
GAIN SAT MEDIUM

FIG.5

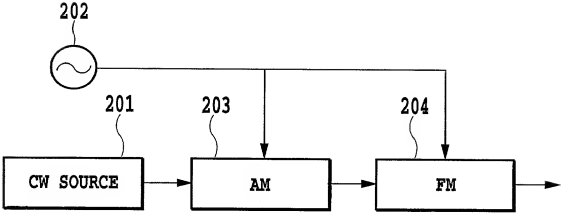
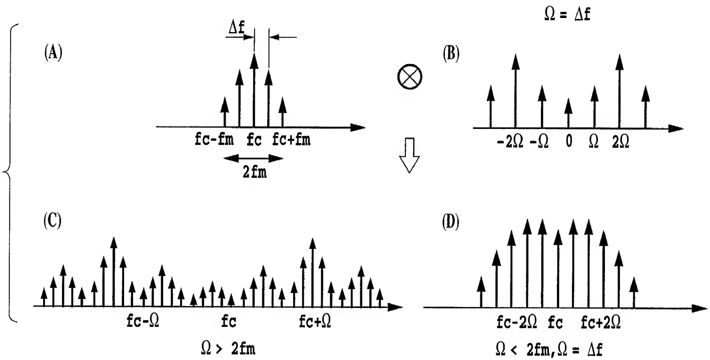


FIG.6

FIG.7


(A)
Δf
fc-fm fc fc+fm
2fm
(B)
Ω = Δf
-2Ω -Ω 0 Ω 2Ω
(C)
fc-Ω fc fc+Ω
Ω > 2fm
(D)
fc-2Ω fc fc+2Ω
Ω < 2fm,Ω = Δf

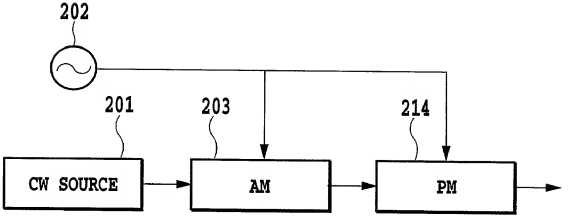


FIG.8

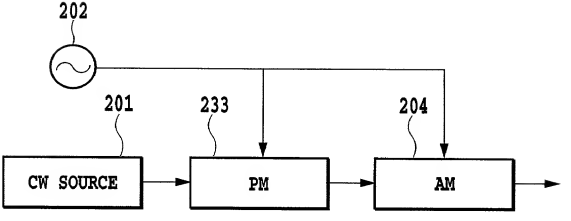


FIG.9

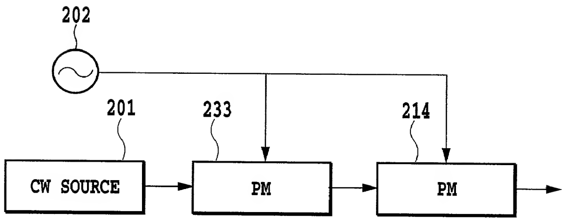


FIG.10

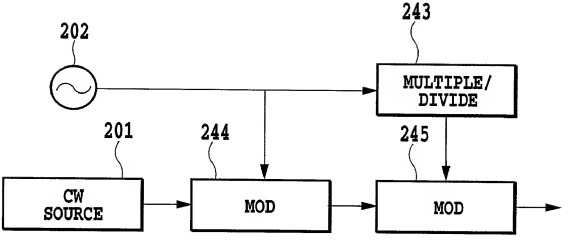


FIG.11

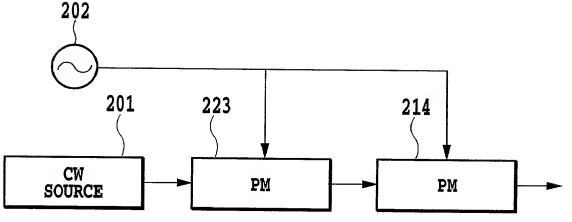


FIG.12

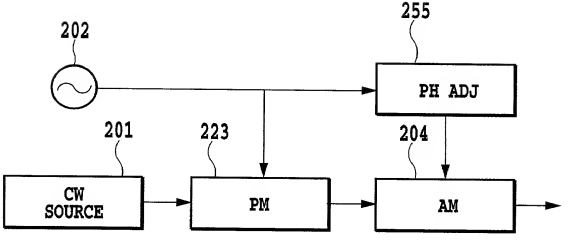


FIG.13

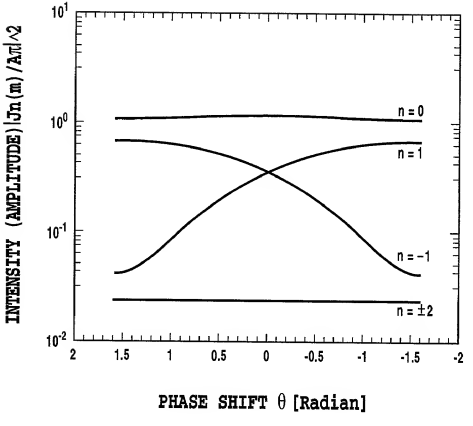
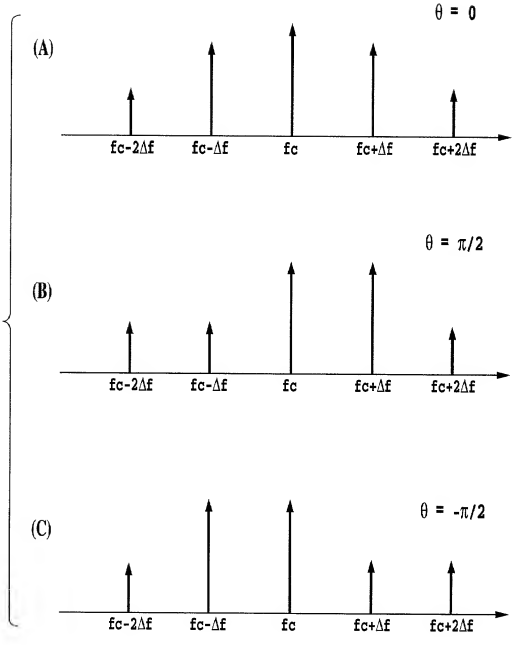


FIG.14

FIG.15



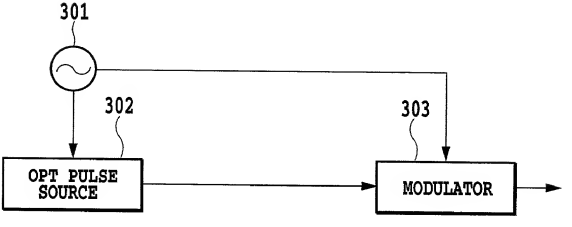


FIG.16

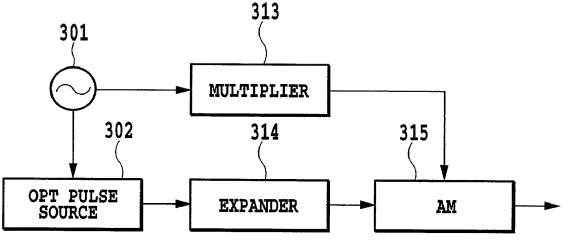


FIG.17

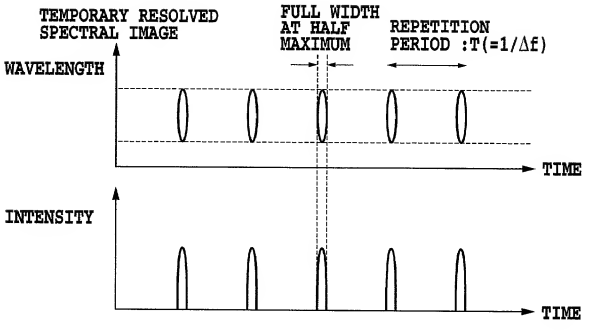

TEMPORARY RESOLVED
SPECTRAL IMAGE
FULL WIDTH
AT HALF
MAXIMUM
REPETITION
PERIOD :T(=1/Δf)
WAVELENGTH
TIME
INTENSITY
TIME

FIG.18

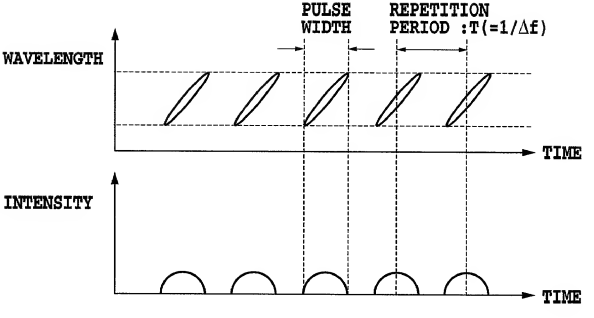


FIG.19

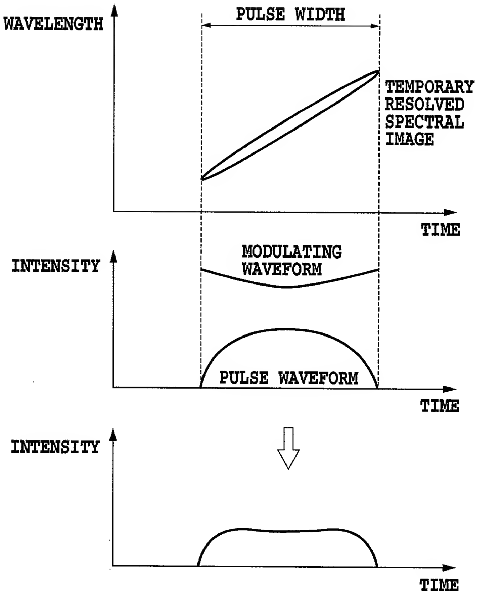

WAVELENGTH
PULSE WIDTH
TEMPORARY RESOLVED SPECTRAL IMAGE
TIME
INTENSITY
MODULATING WAVEFORM
PULSE WAVEFORM
TIME
INTENSITY
TIME

FIG.20

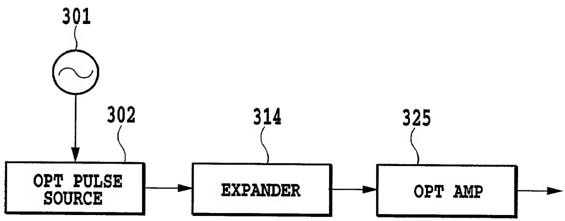


FIG.21

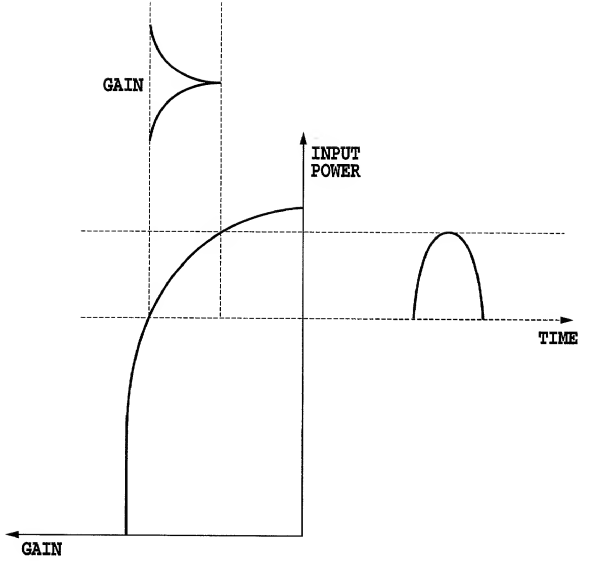


FIG.22

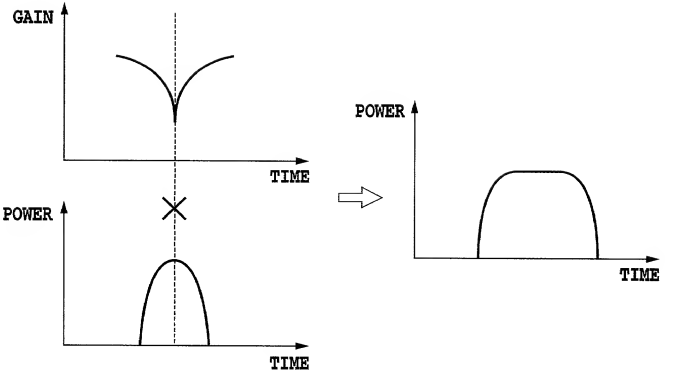


FIG.23

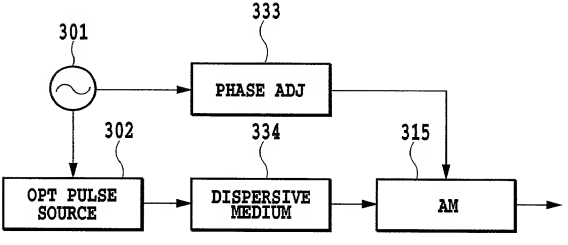


FIG.24

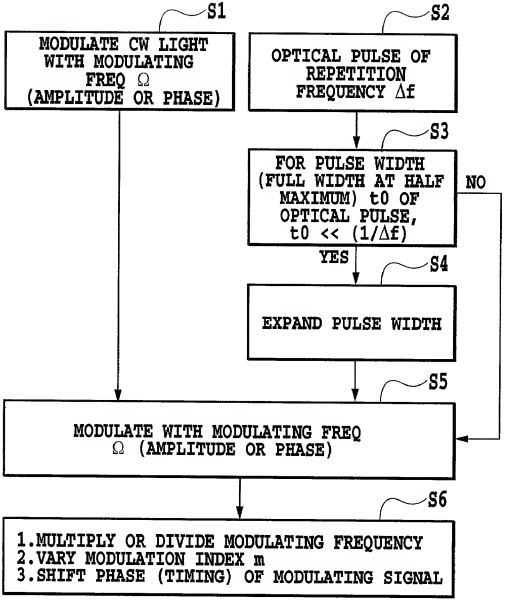


FIG.25

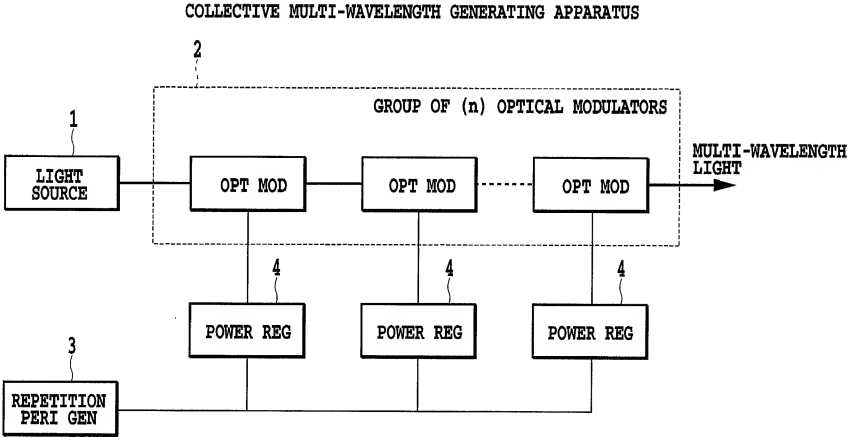

COLLECTIVE MULTI-WAVELENGTH GENERATING APPARATUS
2
GROUP OF (n) OPTICAL MODULATORS
1
LIGHT SOURCE
OPT MOD
OPT MOD
OPT MOD
MULTI-WAVELENGTH LIGHT
4
4
4
POWER REG
POWER REG
POWER REG
3
REPETITION PERI GEN

FIG.26

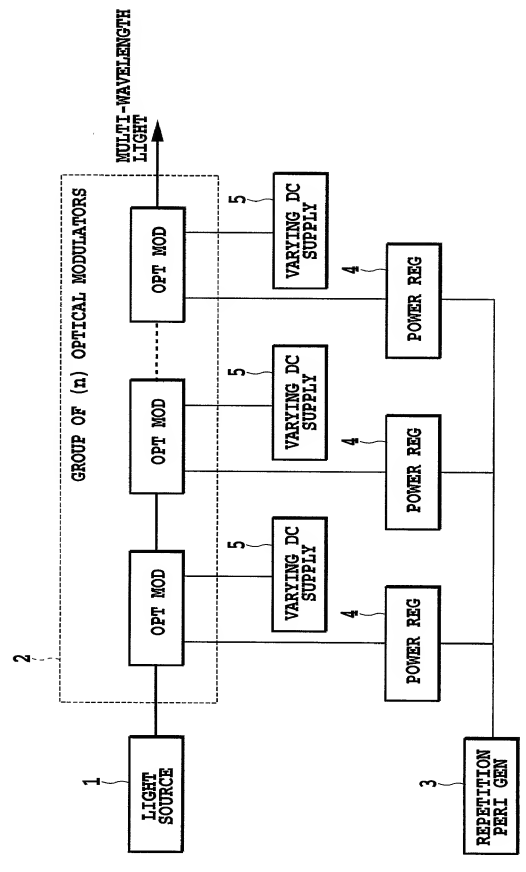


FIG.27

FIG.28

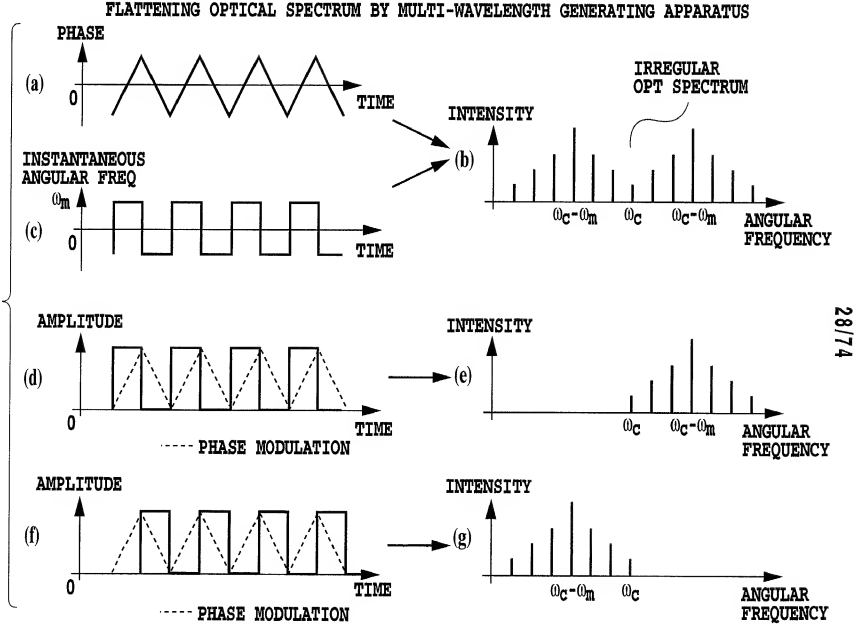
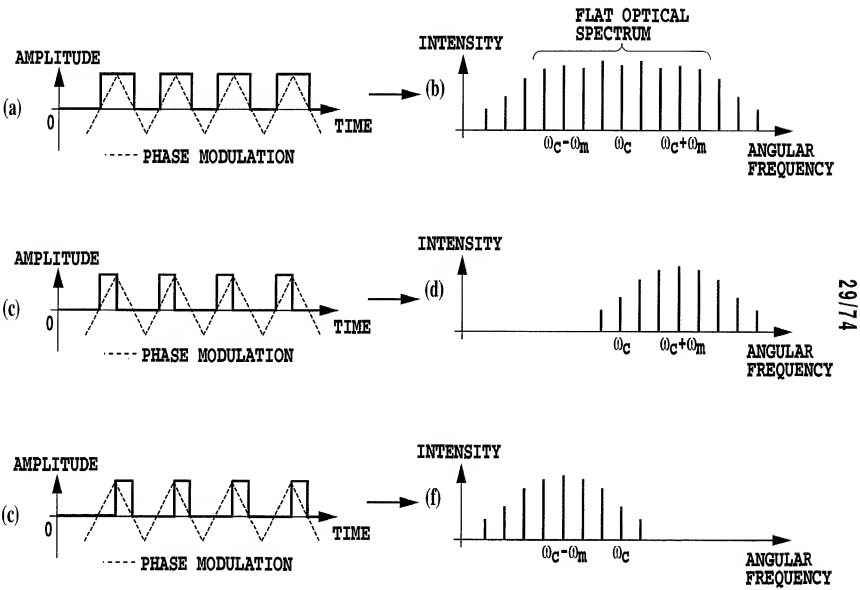

FLATTENING OPTICAL SPECTRUM BY MULTI-WAVELENGTH GENERATING APPARATUS
PHASE
(a)
0
TIME
INSTANTANEOUS
ANGULAR FREQ
ωm
(c)
0
TIME
IRREGULAR
OPT SPECTRUM
INTENSITY
(b)
ωc-ωm
ωc
ωc-ωm
ANGULAR
FREQUENCY
AMPLITUDE
(d)
0
TIME
PHASE MODULATION
INTENSITY
(e)
ωc
ωc-ωm
ANGULAR
FREQUENCY
AMPLITUDE
(f)
0
TIME
PHASE MODULATION
INTENSITY
(g)
ωc-ωm
ωc
ANGULAR
FREQUENCY

FIG.29


AMPLITUDE
(a)
0
TIME
PHASE MODULATION
(b)
INTENSITY
FLAT OPTICAL SPECTRUM
ωc-ωm
ωc
ωc+ωm
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
(d)
INTENSITY
ωc
ωc+ωm
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
(f)
INTENSITY
ωc-ωm
ωc
ANGULAR FREQUENCY

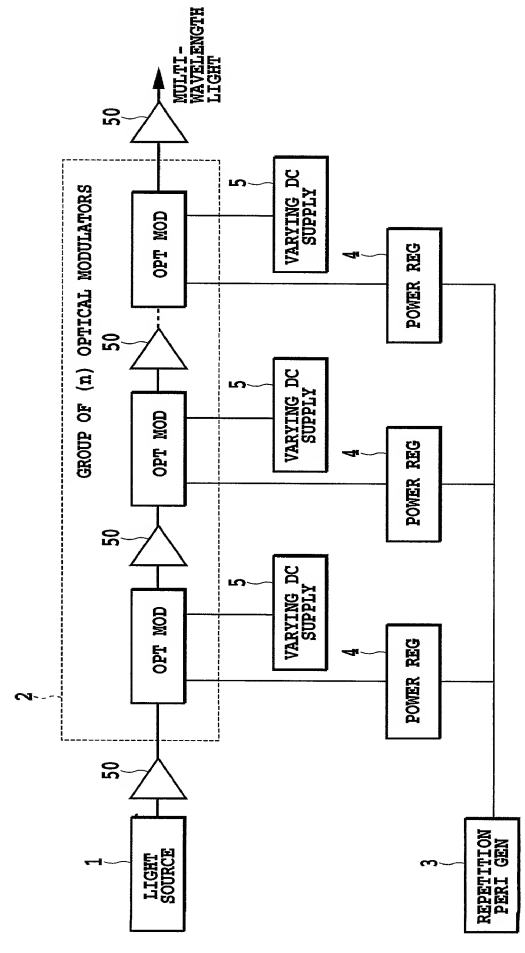

1
LIGHT SOURCE
50
2
GROUP OF (n) OPTICAL MODULATORS
OPT MOD
50
OPT MOD
50
OPT MOD
50
MULTI-WAVELENGTH LIGHT
5
VARYING DC SUPPLY
5
VARYING DC SUPPLY
5
VARYING DC SUPPLY
4
POWER REG
4
POWER REG
4
POWER REG
3
REPETITION FERI GEN

FIG.30

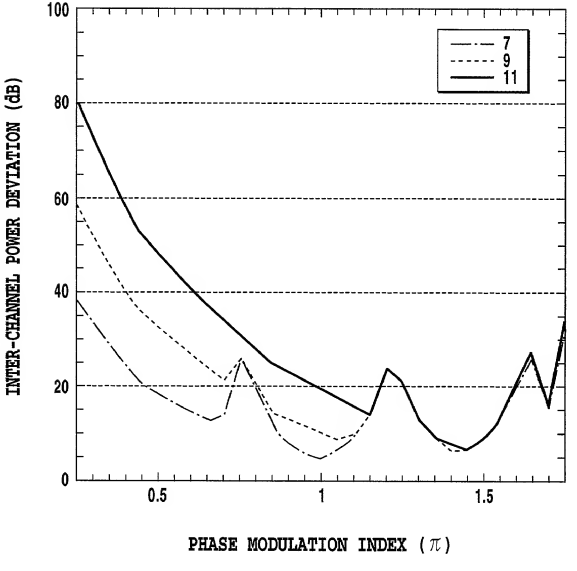
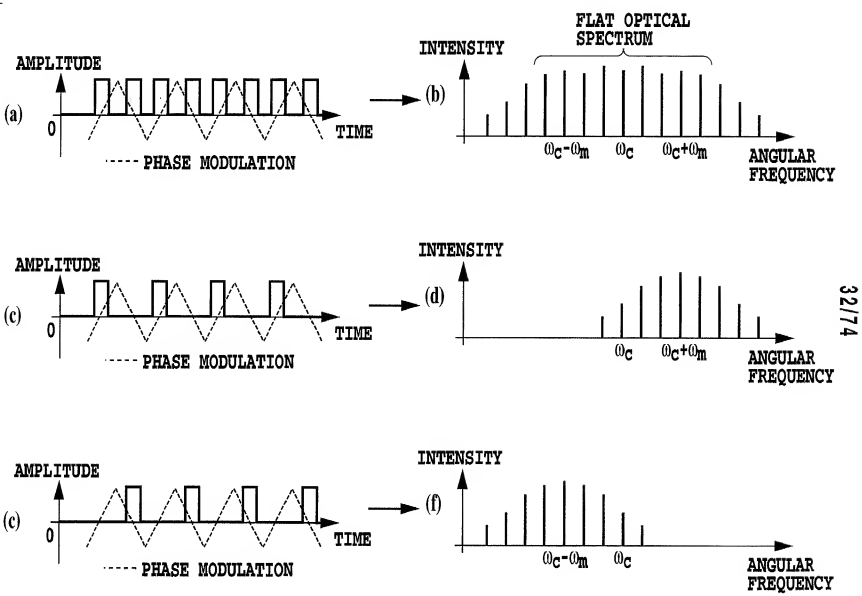

100
80
60
40
20
0
0.5
1
1.5
7
9
11
INTER-CHANNEL POWER DEVIATION (dB)
PHASE MODULATION INDEX (π)

FIG.31

FIG.32


AMPLITUDE
(a)
0
TIME
PHASE MODULATION
INTENSITY
FLAT OPTICAL SPECTRUM
(b)
ωc-ωm
ωc
ωc+ωm
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(d)
ωc
ωc+ωm
ANGULAR FREQUENCY
AMPLITUDE
(c)
0
TIME
PHASE MODULATION
INTENSITY
(f)
ωc-ωm
ωc
ANGULAR FREQUENCY

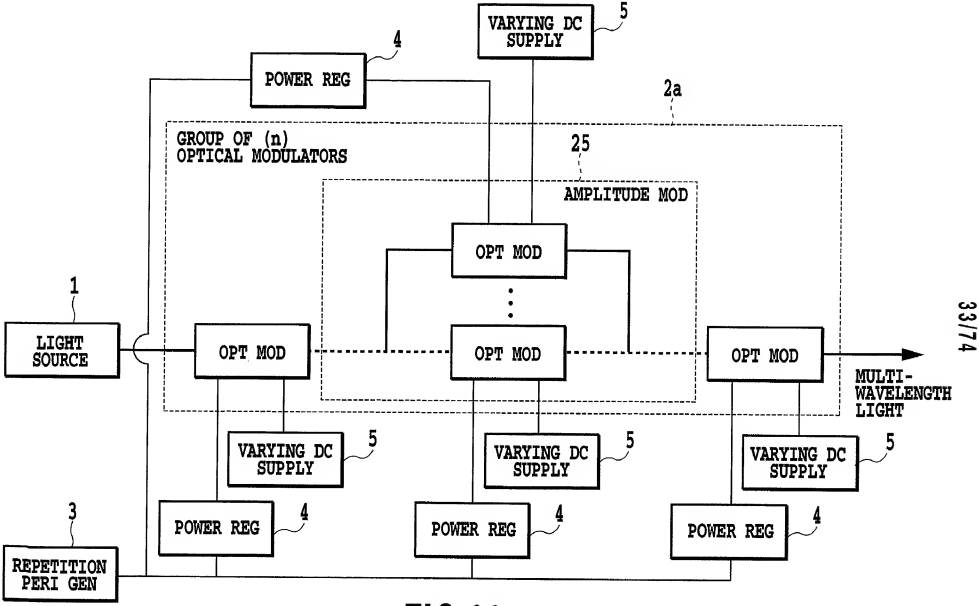

VARYING DC SUPPLY
5
POWER REG
4
2a
GROUP OF (n) OPTICAL MODULATORS
25
AMPLITUDE MOD
OPT MOD
OPT MOD
OPT MOD
OPT MOD
1
LIGHT SOURCE
MULTI-WAVELENGTH LIGHT
VARYING DC SUPPLY
5
VARYING DC SUPPLY
5
VARYING DC SUPPLY
5
3
REPETITION PERI GEN
POWER REG
4
POWER REG
4
POWER REG
4

FIG.33

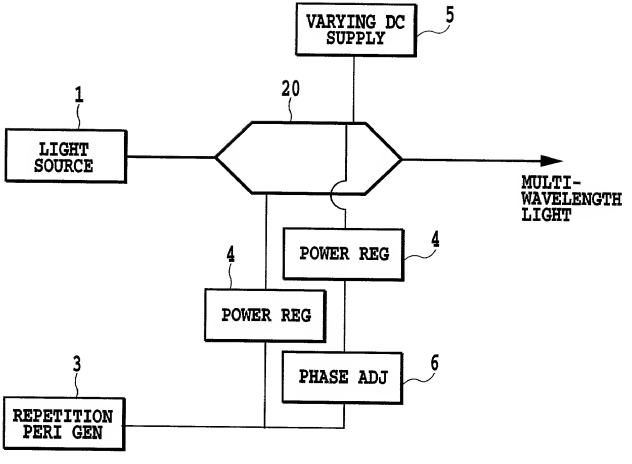

VARYING DC SUPPLY
5
1
20
LIGHT SOURCE
MULTI-WAVELENGTH LIGHT
4
POWER REG
4
POWER REG
3
PHASE ADJ
6
REPETITION PERI GEN

FIG.34

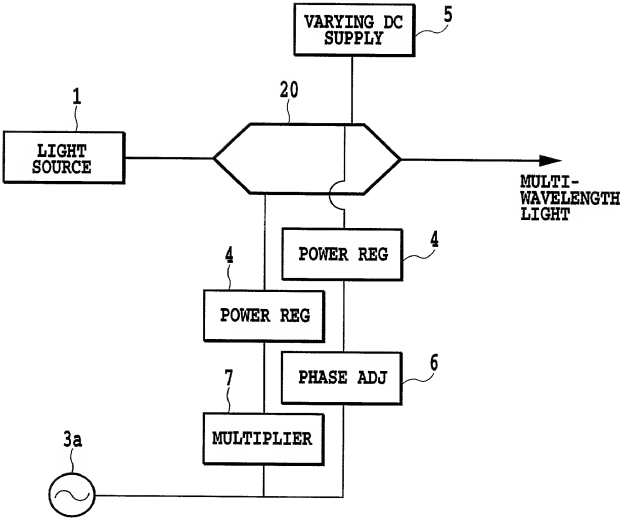

VARYING DC SUPPLY
5
1
20
LIGHT SOURCE
MULTI-WAVELENGTH LIGHT
4
POWER REG
4
POWER REG
7
PHASE ADJ
6
MULTIPLIER
3a

FIG.35

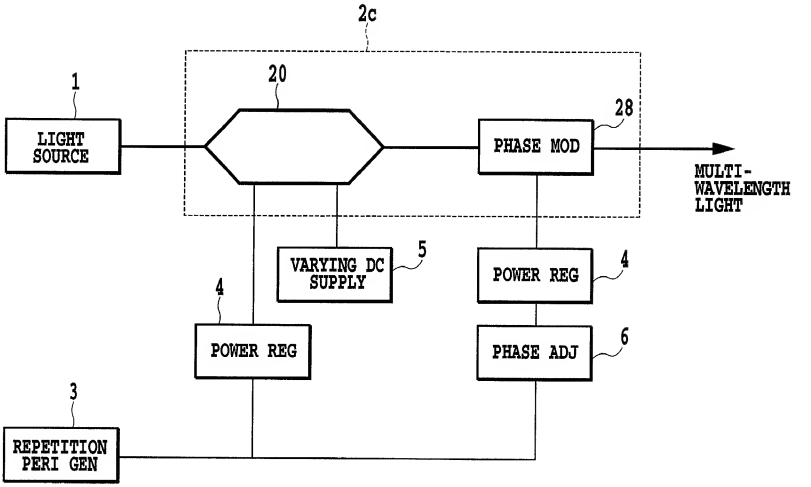

2c
1
LIGHT SOURCE
20
28
PHASE MOD
MULTI-WAVELENGTH LIGHT
VARYING DC SUPPLY
5
4
POWER REG
4
POWER REG
PHASE ADJ
6
3
REPETITION PERI GEN

FIG.36

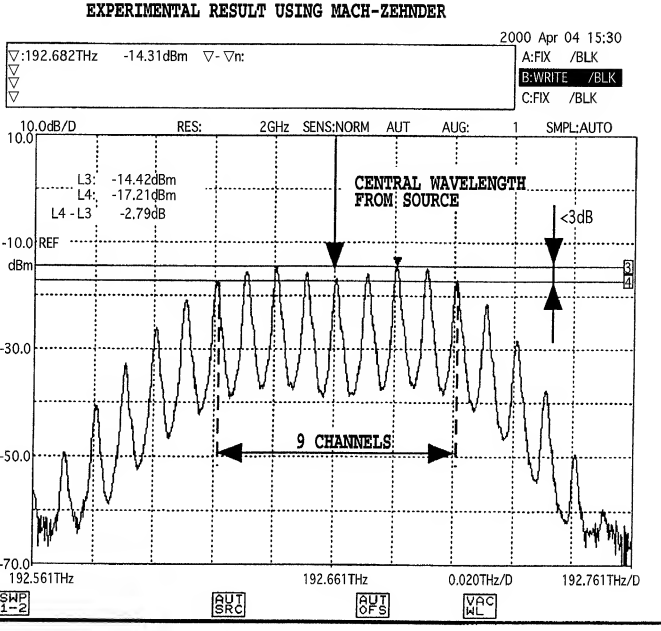

EXPERIMENTAL RESULT USING MACH-ZEHNDER
2000 Apr 04 15:30
▽:192.682THz -14.31dBm ▽-▽n:
A:FIX /BLK
B:WRITE /BLK
C:FIX /BLK
10.0dB/D
RES: 2GHz SENS:NORM AUT AUG: 1 SMPL:AUTO
10.0
L3: -14.42dBm
L4: -17.21dBm
L4 - L3 -2.79dB
CENTRAL WAVELENGTH FROM SOURCE
<3dB
-10.0 REF
dBm
-30.0
-50.0
9 CHANNELS
-70.0
192.561THz
192.661THz
0.020THz/D
192.761THz/D
SWP 1-2
AUT SRC
AUT OFS
VAC WL

FIG.37

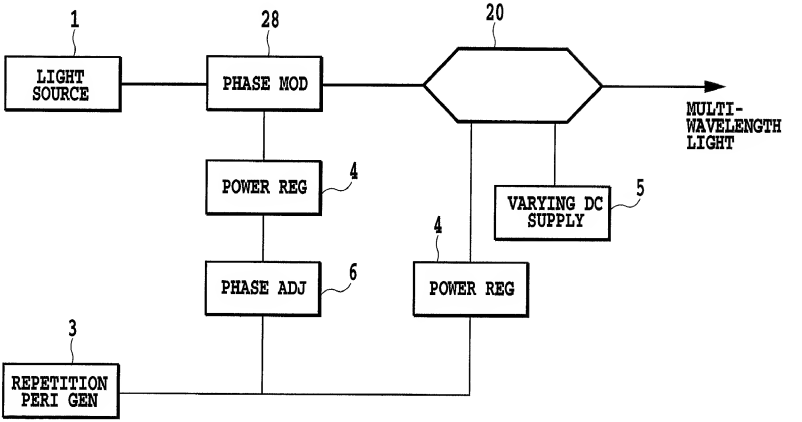

1
LIGHT SOURCE
28
PHASE MOD
20
MULTI-WAVELENGTH LIGHT
POWER REG
4
VARYING DC SUPPLY
5
4
PHASE ADJ
6
POWER REG
3
REPETITION PERI GEN

FIG.38

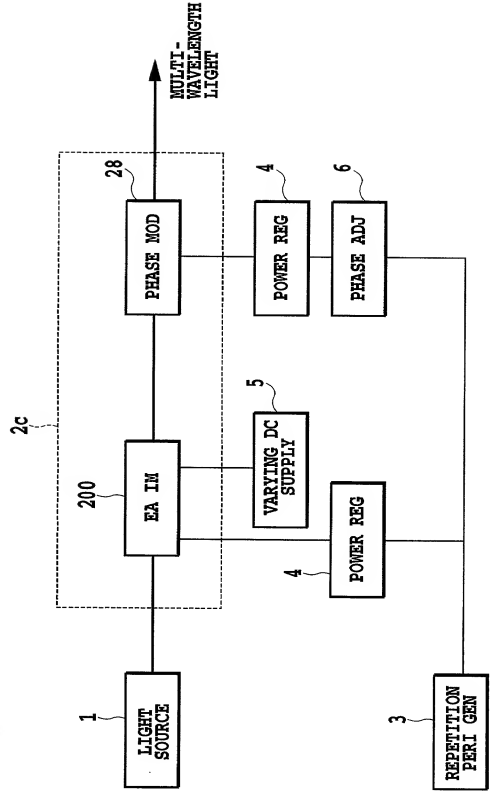

1
LIGHT SOURCE
3
REPETITION PERI GEN
2c
200
EA IM
4
POWER REG
5
VARYING DC SUPPLY
28
PHASE MOD
4
POWER REG
6
PHASE ADJ
MULTI-WAVELENGTH LIGHT

FIG.39

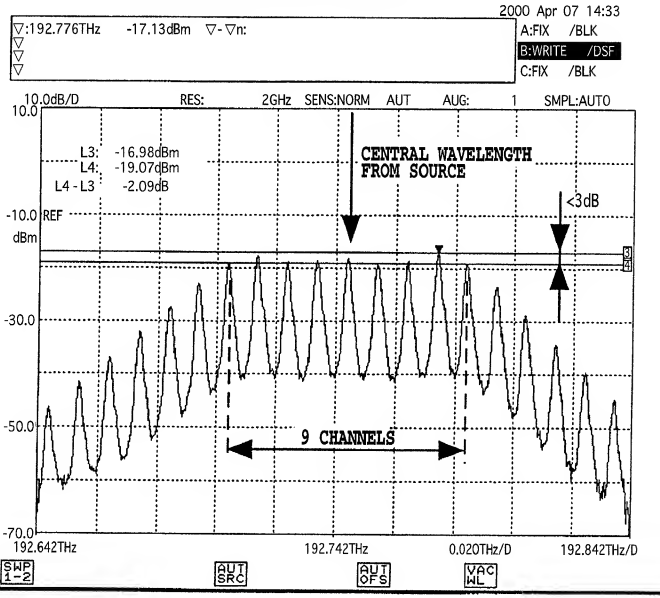

EXPERIMENTAL RESULT USING EA IM
2000 Apr 07 14:33
▽:192.776THz -17.13dBm ▽-▽n:
A:FIX /BLK
B:WRITE /DSF
C:FIX /BLK
10.0dB/D
RES: 2GHz SENS:NORM AUT AUG: 1 SMPL:AUTO
10.0
L3: -16.98dBm
L4: -19.07dBm
L4 - L3 -2.09dB
CENTRAL WAVELENGTH FROM SOURCE
<3dB
-10.0 REF
dBm
-30.0
-50.0
9 CHANNELS
-70.0
192.642THz
192.742THz
0.020THz/D
192.842THz/D
SWP 1-2
AUT SRC
AUT OFS
VAC WL

FIG.40

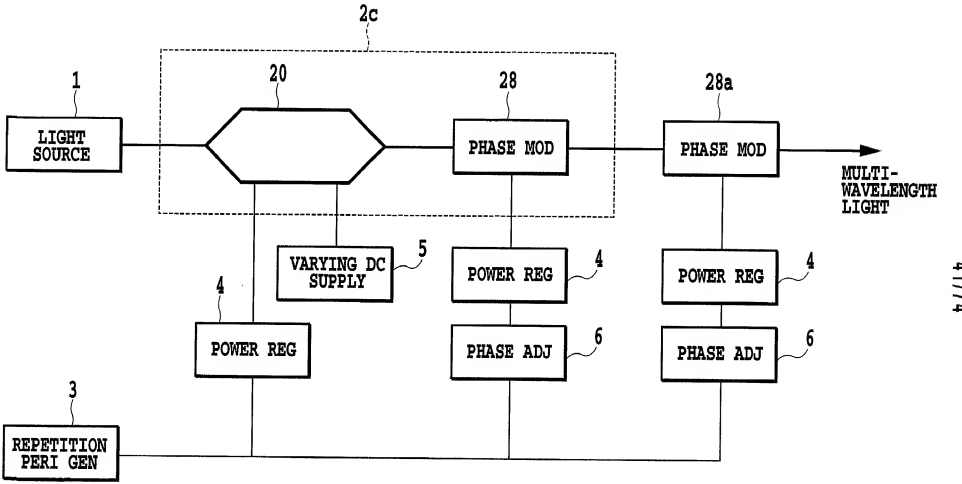

2c
1
20
28
28a
LIGHT SOURCE
PHASE MOD
PHASE MOD
MULTI-WAVELENGTH LIGHT
VARYING DC SUPPLY
5
4
POWER REG
4
POWER REG
4
POWER REG
PHASE ADJ
6
PHASE ADJ
6
3
REPETITION PERI GEN

FIG.41

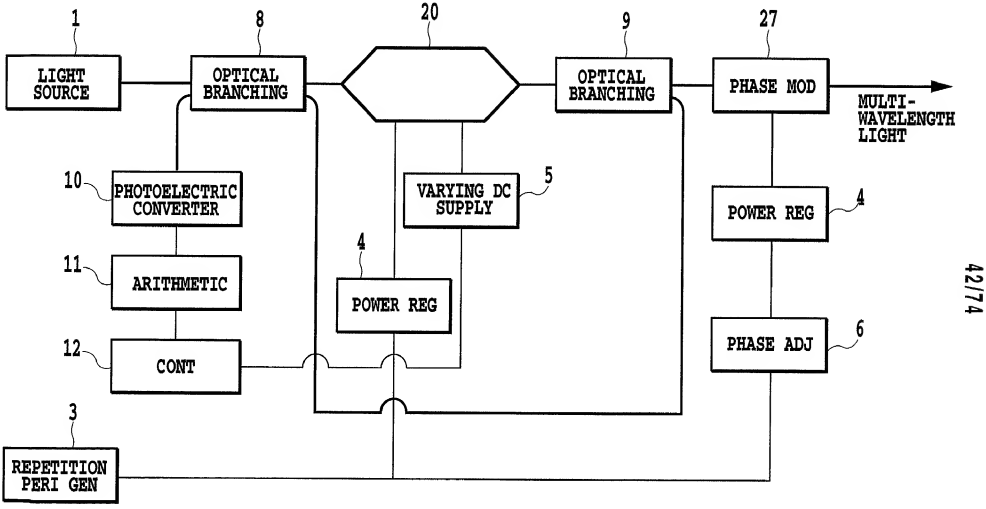


FIG.42

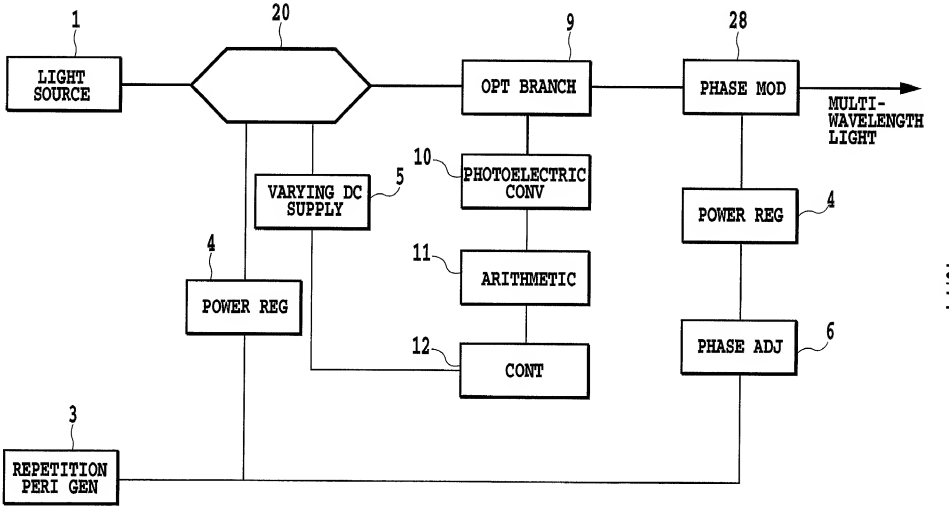

1
LIGHT SOURCE
20
9
OPT BRANCH
28
PHASE MOD
MULTI-WAVELENGTH LIGHT
10
PHOTOELECTRIC CONV
VARYING DC SUPPLY
5
4
POWER REG
11
ARITHMETIC
12
CONT
4
POWER REG
6
PHASE ADJ
3
REPETITION PERI GEN

FIG.43

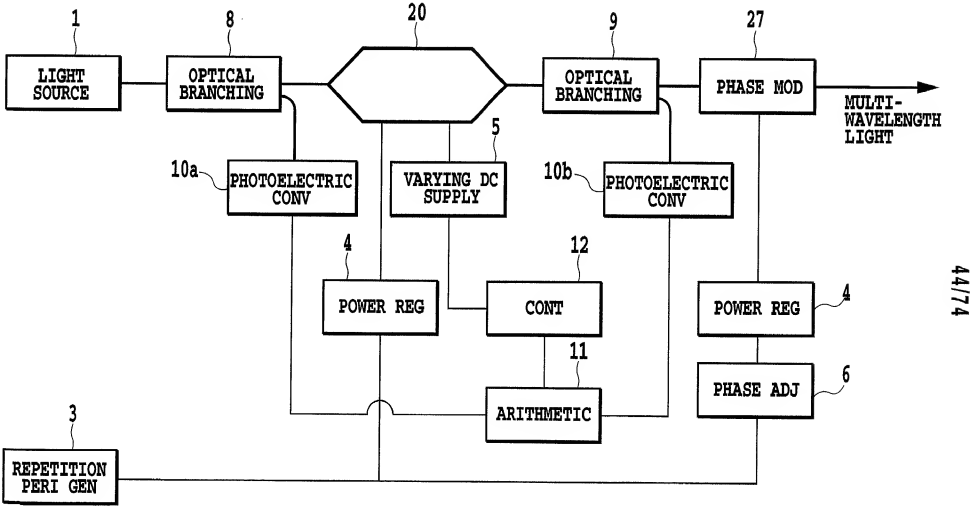

1
LIGHT SOURCE
8
OPTICAL BRANCHING
20
9
OPTICAL BRANCHING
27
PHASE MOD
MULTI-WAVELENGTH LIGHT
10a
PHOTOELECTRIC CONV
5
VARYING DC SUPPLY
10b
PHOTOELECTRIC CONV
4
POWER REG
12
CONT
POWER REG
4
11
PHASE ADJ
6
ARITHMETIC
3
REPETITION PERI GEN

FIG.44

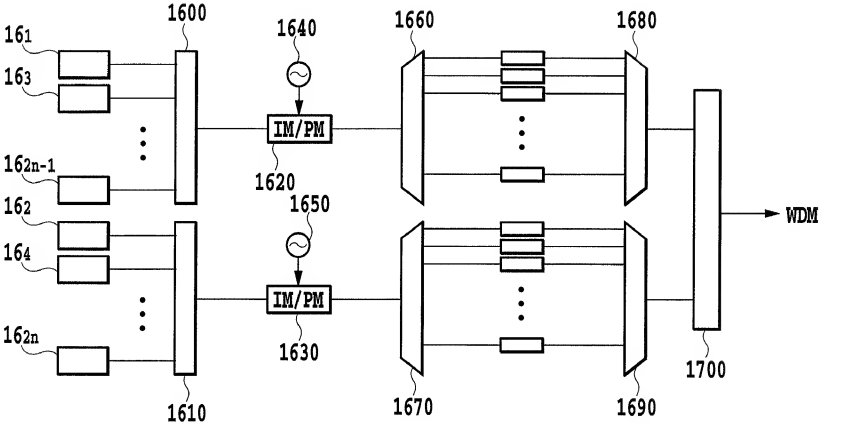


FIG.45

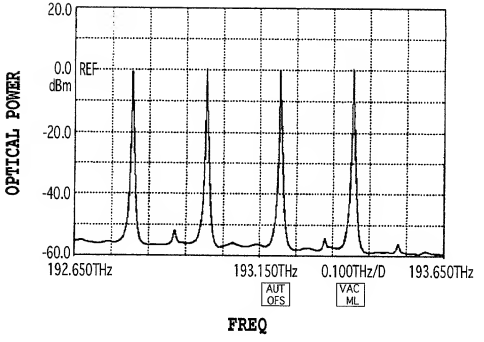


FIG.46A

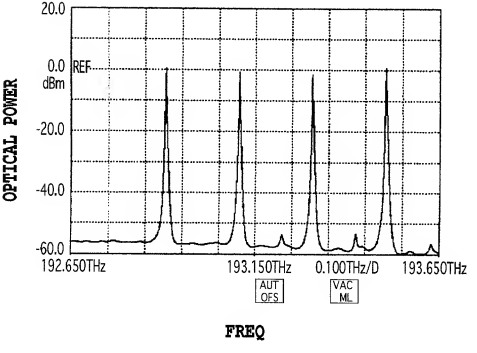


FIG.46B

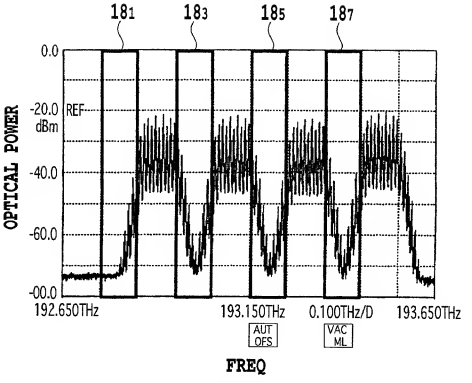


FIG.47A

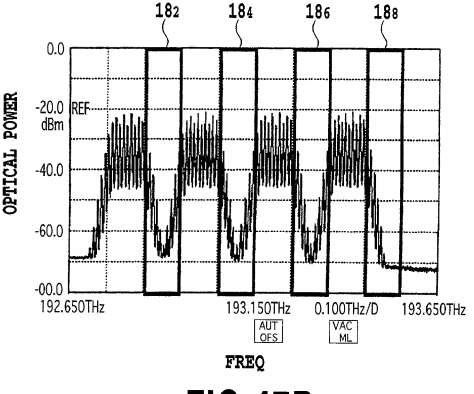


FIG.47B

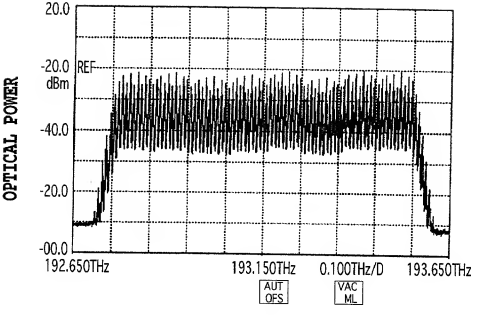

20.0
-20.0 REF
dBm
-40.0
-20.0
-00.0
OPTICAL POWER
192.650THz
193.150THz
AUT
OFS
0.100THz/D
VAC
ML
193.650THz
FREQ

FIG.48

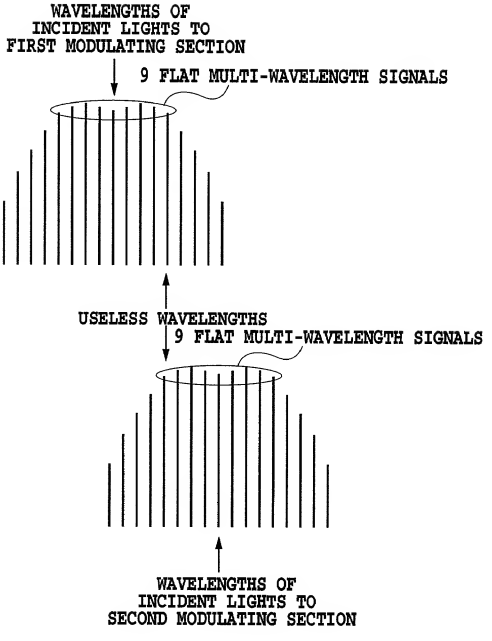


FIG.49A

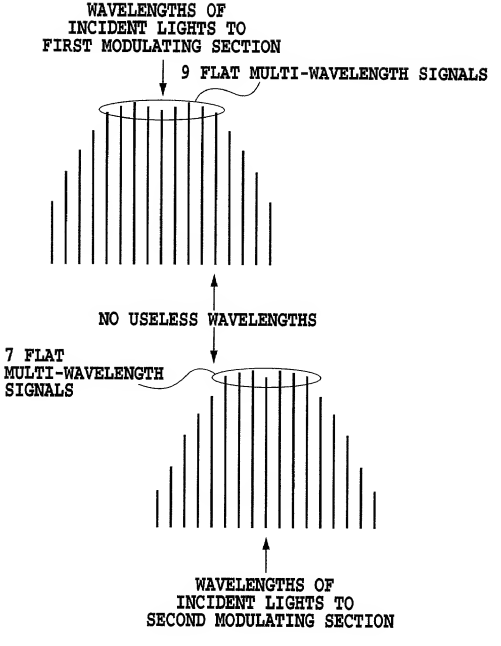

WAVELENGTHS OF
INCIDENT LIGHTS TO
FIRST MODULATING SECTION
9 FLAT MULTI-WAVELENGTH SIGNALS
NO USELESS WAVELENGTHS
7 FLAT
MULTI-WAVELENGTH
SIGNALS
WAVELENGTHS OF
INCIDENT LIGHTS TO
SECOND MODULATING SECTION

FIG.49B

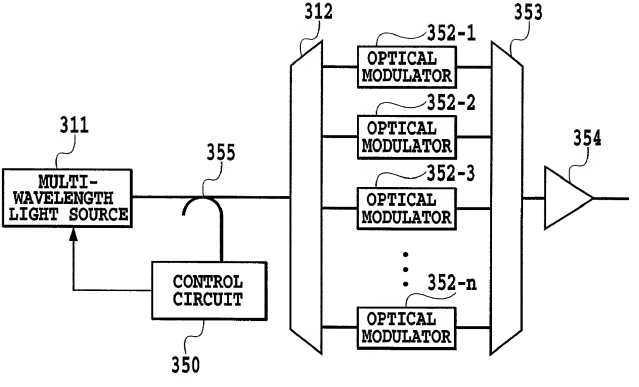

312
353
352-1
OPTICAL MODULATOR
352-2
OPTICAL MODULATOR
352-3
OPTICAL MODULATOR
352-n
OPTICAL MODULATOR
311
MULTI-WAVELENGTH LIGHT SOURCE
355
354
CONTROL CIRCUIT
350

FIG.50

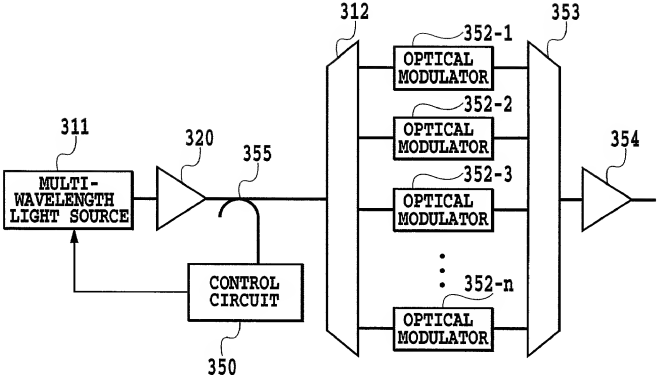

312
353
352-1
OPTICAL MODULATOR
352-2
OPTICAL MODULATOR
354
311
320
355
MULTI-WAVELENGTH LIGHT SOURCE
352-3
OPTICAL MODULATOR
CONTROL CIRCUIT
352-n
OPTICAL MODULATOR
350

FIG.51

WAVELENGTH-MULTIPLEXED TRANSMISSION SYSTEM USING
COHERENT MULTI-WAVELENGTH SIGNAL GENERATING APPARATUS

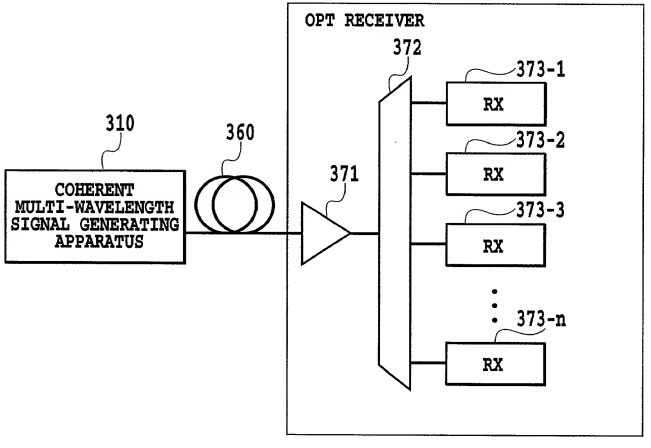


FIG.52

EXAMPLE OF FIRST CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE

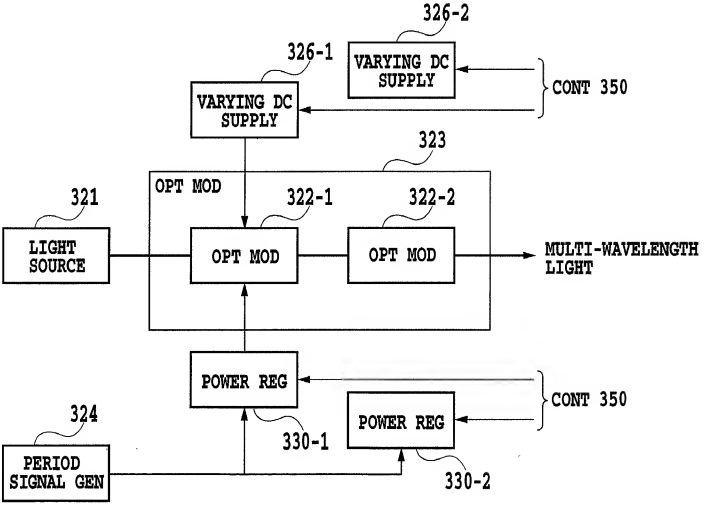


FIG.53

FIG. 53 PRINCIPLE OF GENERATION OF MULTI-WAVELENGTH LIGHT FROM MULTI-WAVELENGTH LIGHT SOURCE

FIG.54

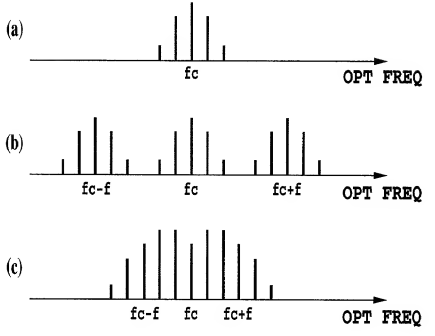
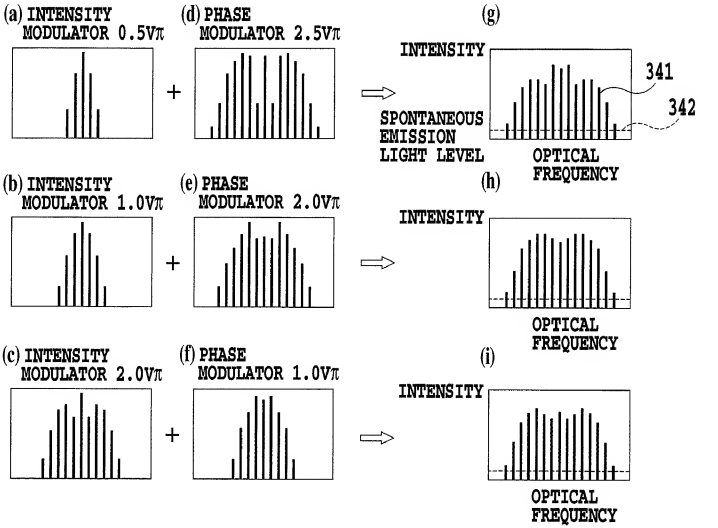


FIG.55


SHAPE CONTROL OF OPTICAL SPECTRUM USING INTENSITY AND PHASE MODULATORS AS OPTICAL MODULATING SECTION
(a) INTENSITY MODULATOR 0.5Vπ
(d) PHASE MODULATOR 2.5Vπ
(g)
INTENSITY
341
342
SPONTANEOUS EMISSION LIGHT LEVEL
OPTICAL FREQUENCY
(b) INTENSITY MODULATOR 1.0Vπ
(e) PHASE MODULATOR 2.0Vπ
(h)
INTENSITY
OPTICAL FREQUENCY
(c) INTENSITY MODULATOR 2.0Vπ
(f) PHASE MODULATOR 1.0Vπ
(i)
INTENSITY
OPTICAL FREQUENCY

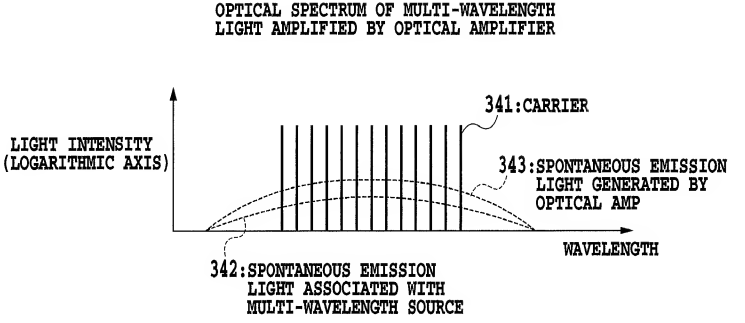


FIG.56

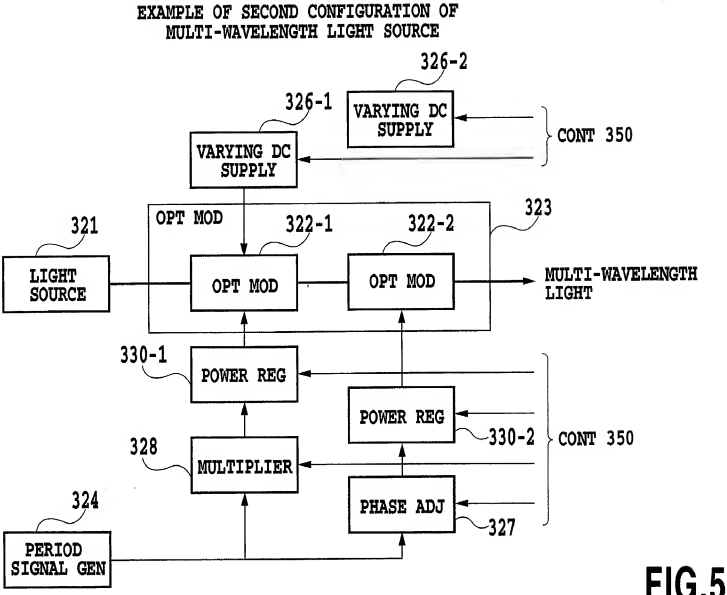

EXAMPLE OF SECOND CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE
326-2
326-1
VARYING DC SUPPLY
VARYING DC SUPPLY
CONT 350
OPT MOD
321
322-1
322-2
323
LIGHT SOURCE
OPT MOD
OPT MOD
MULTI-WAVELENGTH LIGHT
330-1
POWER REG
POWER REG
330-2
CONT 350
328
MULTIPLIER
PHASE ADJ
327
324
PERIOD SIGNAL GEN

FIG.57

FIG.58

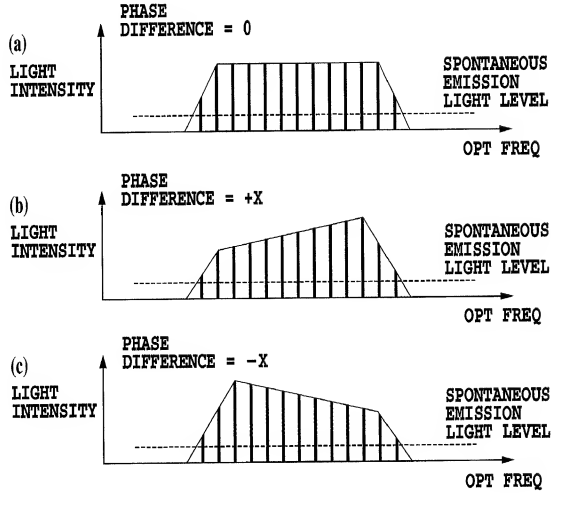
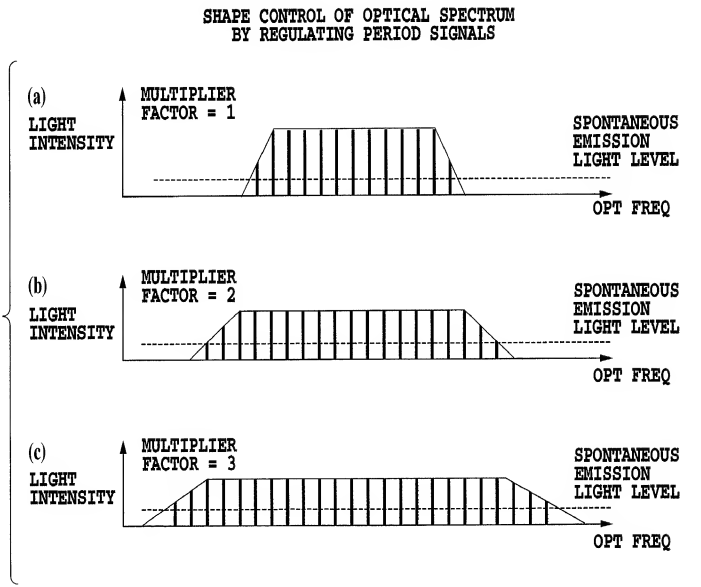

SHAPE CONTROL OF OPTICAL SPECTRUM
BY REGULATING PHASES OF PERIOD SIGNALS
(a)
PHASE
DIFFERENCE = 0
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(b)
PHASE
DIFFERENCE = +X
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(c)
PHASE
DIFFERENCE = -X
LIGHT
INTENSITY
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ

FIG.59


SHAPE CONTROL OF OPTICAL SPECTRUM
BY REGULATING PERIOD SIGNALS
(a)
LIGHT
INTENSITY
MULTIPLIER
FACTOR = 1
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(b)
LIGHT
INTENSITY
MULTIPLIER
FACTOR = 2
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ
(c)
LIGHT
INTENSITY
MULTIPLIER
FACTOR = 3
SPONTANEOUS
EMISSION
LIGHT LEVEL
OPT FREQ

EXAMPLE OF THIRD CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE

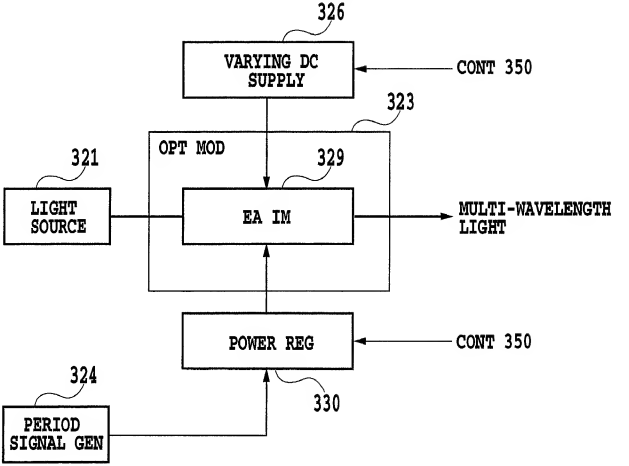


FIG.60

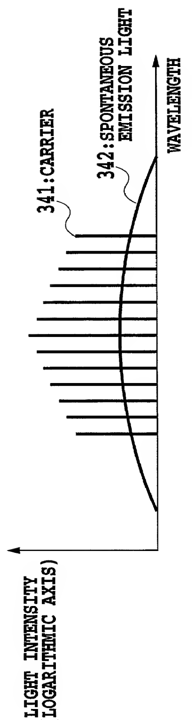

341:CARRIER
342:SPONTANEOUS EMISSION LIGHT
WAVELENGTH
LIGHT INTENSITY (LOGARITHMIC AXIS)

FIG.61

FOURTH EXAMPLE OF CONFIGURATION OF MULTI-WAVELENGTH LIGHT SOURCE

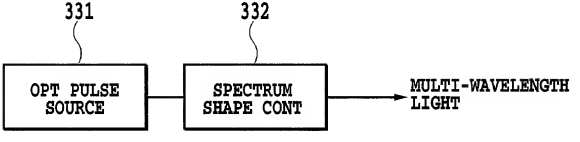


FIG.62

PRINCIPLE OF ADIABATIC COMPRESSION WITH DISPERSION REDUCING FIBER

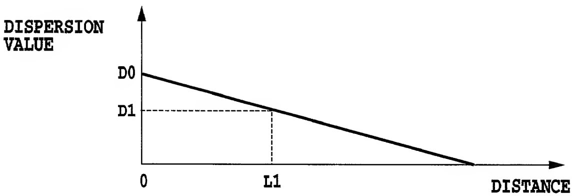
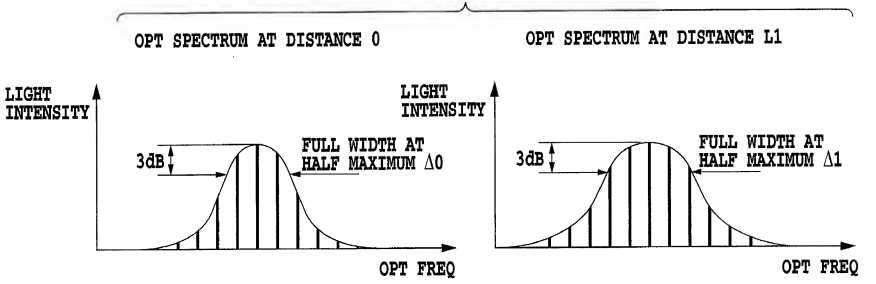


FIG.63A



$\Delta 1 / \Delta 0 = D0 / D1$

FIG.63B

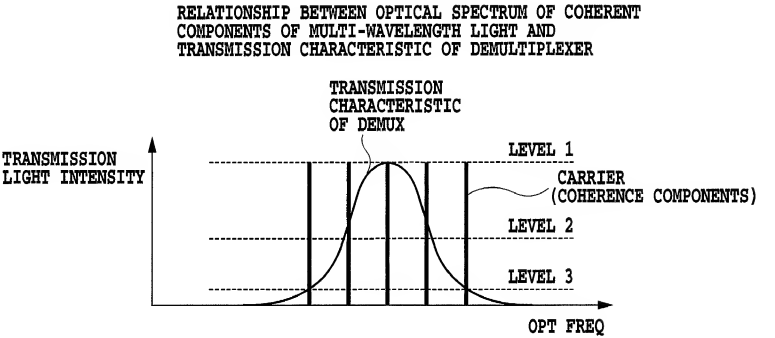

RELATIONSHIP BETWEEN OPTICAL SPECTRUM OF COHERENT COMPONENTS OF MULTI-WAVELENGTH LIGHT AND TRANSMISSION CHARACTERISTIC OF DEMULTIPLEXER
TRANSMISSION CHARACTERISTIC OF DEMUX
TRANSMISSION LIGHT INTENSITY
LEVEL 1
CARRIER (COHERENCE COMPONENTS)
LEVEL 2
LEVEL 3
OPT FREQ

FIG.64

RELATIONSHIP BETWEEN STIMULATED EMISSION LIGHT AND SPONTANEOUS EMISSION LIGHT FROM SEMICONDUCTOR LASER

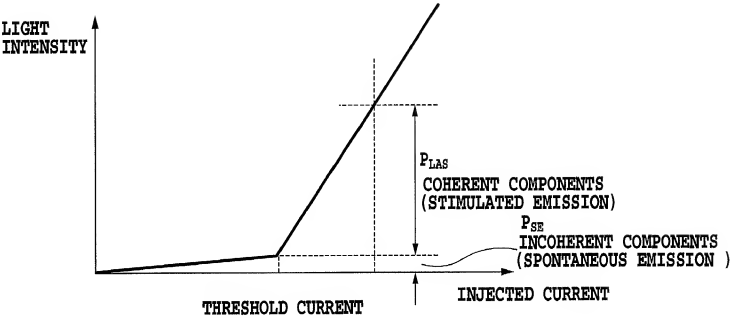


FIG.65

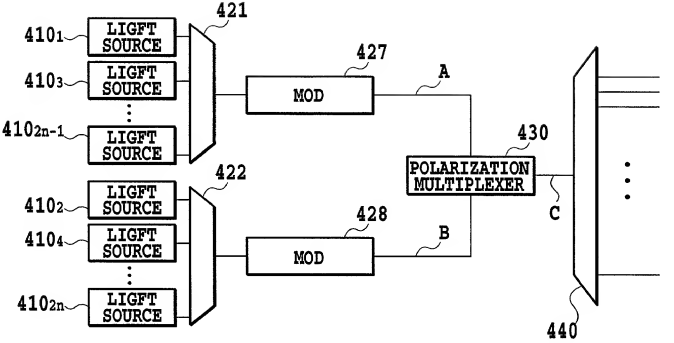
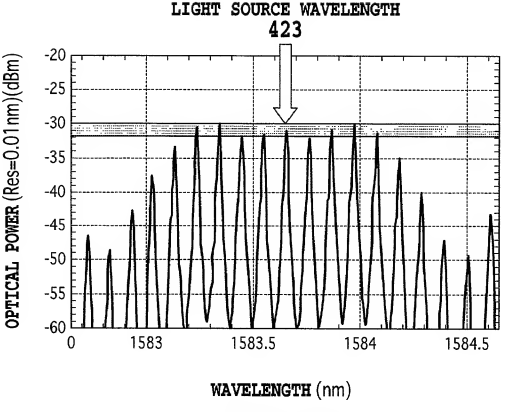
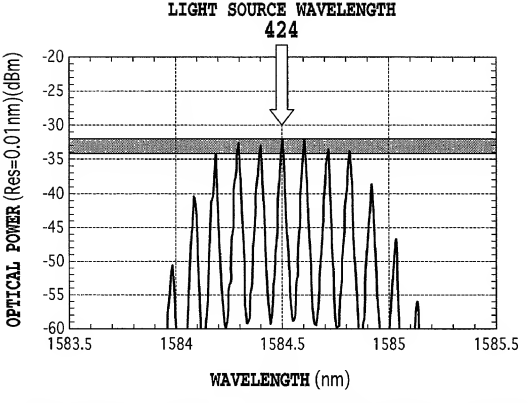

421
410_1
LIGFT SOURCE
410_3
LIGFT SOURCE
410_{2n-1}
LIGFT SOURCE
427
MOD
A
430
POLARIZATION MULTIPLEXER
422
410_2
LIGFT SOURCE
410_4
LIGFT SOURCE
410_{2n}
LIGFT SOURCE
428
MOD
B
C
440

FIG.66



ODD-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES

FIG.67A



EVEN-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES

FIG.67B

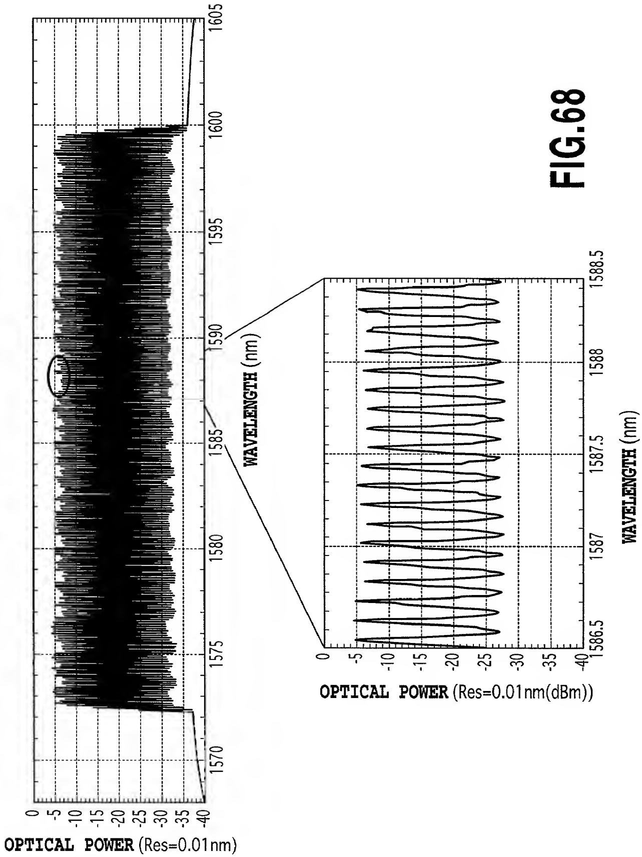

OPTICAL POWER (Res=0.01nm)
0
-5
-10
-15
-20
-25
-30
-35
-40
1570
1575
1580
1585
1590
1595
1600
1605
WAVELENGTH (nm)
OPTICAL POWER (Res=0.01nm(dBm))
1586.5
1587
1587.5
1588
1588.5
WAVELENGTH (nm)

FIG.68

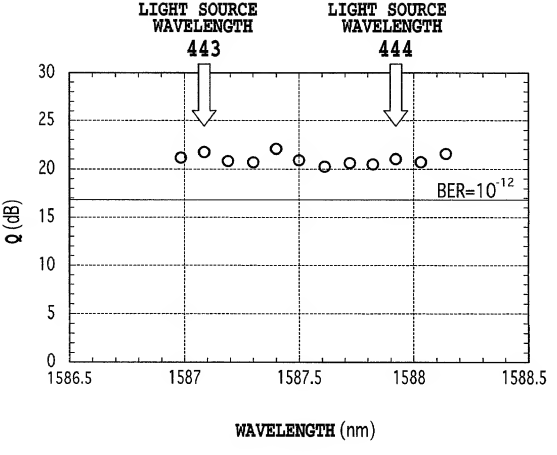


FIG.69

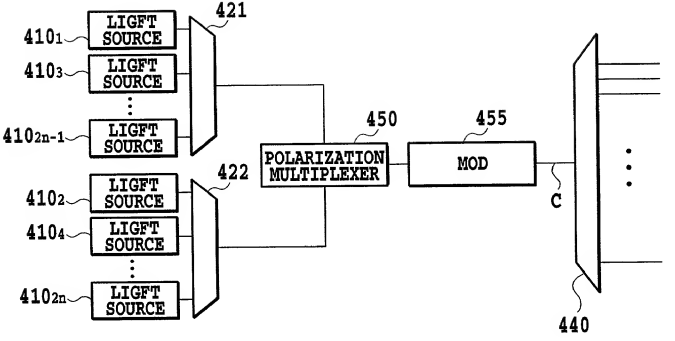

LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
LIGFT SOURCE
421
422
450
455
POLARIZATION MULTIPLEXER
MOD
C
440

FIG.70

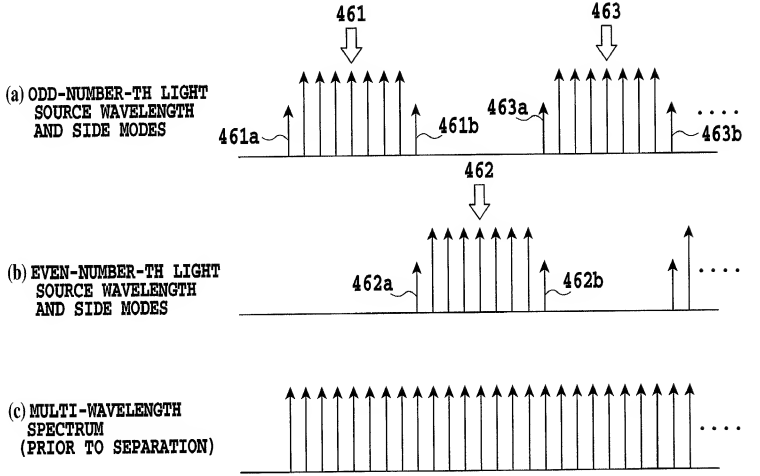

461
463
(a) ODD-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES
461a
461b
463a
463b
462
(b) EVEN-NUMBER-TH LIGHT SOURCE WAVELENGTH AND SIDE MODES
462a
462b
(c) MULTI-WAVELENGTH SPECTRUM (PRIOR TO SEPARATION)

FIG.71